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Spruce Budworm
CONTROL

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EXPERIMENTAL SPRAYING FOR THE CONTROL OF THE SPRUCE BUDWORM IN THE CODY CANYON, SHOSHONE NATIONAL FOREST 1930

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INTRODUCTION

The first report of the spruce budworm (Cacoecia fumiferana) within the Douglas Fir stands of the Cody Canyon, Wyoming, was received in July, 1922. At that time the outbreak was confined to one rather small drainage, but in the past eight years it has spread over a large acreage, and a serious epidemic exists that is viewed with alarm by the citizens of that region. The Cody Canyon is the most popular entrance to the Yellowstone National Park for automobile traffic, and the rugged mountain sides, with their fantastic rock formations rising for thousands of feet above the floor of the canyon, delighting the eyes of thousands of tourists annually, depend upon the forests of Douglas fir for their beautiful setting.

In addition to the scenic value of these forests to the canyon which is seen by tourists, many dude ranches, summer homes, and public campgrounds depend entirely upon these Douglas fir stands for the beauty of their sites. With the spread of this epidemic into the forests noticeable to the layman, public opinion became insistent that something be done to prevent further destruction of these timber stands in order to preserve the beauty and economic values of the region.

SEASONAL HISTORY SPRUCE BUDWORM

In view of statements that are to be made later, the inclusion of a brief discussion of the seasonal history of the spruce budworm within this report would seem to be necessary. The adult insects, which are small, brownish moths with a wing expanse of approximately one inch, are to be seen flying in late July and early August. During this flight period eggs are laid in light-green, inconspicuous masses along the under side of the needles. These eggs hatch in 10 to 12 days, and the young larvae construct small cocoons under flakes of bark or in other sheltered places in which they pass the winter. It is not definitely known if these young larvae feed before hibernation or not, but if they do it is very sparingly. The following spring the over-wintering larvae leave their cocoons and bore into the swelling leaf buds. The worms, or larvae, develop very rapidly and are usually mature by the middle of July. When mature, the larvae are approximately one inch in length, of a deep brown color, with yellowish, pale green markings and numerous wart-like growths along the sides. At this stage the mature larvae pupate within chrysalids attached by a few silken threads to twigs and other objects. The pupal stage of this insect lasts from 10 to 12 days. There is but one generation per year.

RESUME OF 1929 EXPERIMENTAL WORK

Realization of the importance of the situation within the Cody Canyon, that was increasing in seriousness annually, resulted in the sum of $300 from the annual forest insect control appropriation, being made available to the Shoshone National Forest for the fiscal year of 1929. This appropriation was made for the purpose of testing the possibilities of controlling outbreaks of this insect, through the application of certain sprays that had proven satisfactory with other insects. Due to the size of this appropriation, equipment suitable for the spraying of forest trees could not be secured, and it was necessary to attempt the experiment with a small portable "Evinrude" forest-fire pump. This inadequate equipment gave to the experiment the twofold purpose of testing the effectiveness of the spray and the possibility of adapting pumps of this character to the spraying of forest trees.* Though this project was regarded as an experiment, it actually developed into potential control around several of the dude ranches, where the infestation was the heaviest. A standard lead-arsenate, fish-oil spray was used, the formula being the one giving the greatest success in the control of the gypsy moth in the eastern United States.

The results of this experiment were not at all satisfactory. Though pumps of this character might be adapted to the spraying of small trees of high aesthetic value, their use in the spraying of tall forest trees is impossible. With this equipment such factors as the lack of

* A report of this experiment was submitted by J. C. Evenden in 1930.

pressure, difficulty of mixing and agitating the spray mixture within the barrels from which the liquid was pumped, gallonage delivered per minute, height to which the stream could be thrown, as well as other factors of operation, etc., made further consideration of such pumps for projects of this character an impossibility. The effectiveness of the spray was equally as discouraging. With the low pressure developed, it was impossible to secure the proper breakage of the stream thrown from a small-sized Worthley nozzle, which is essential for proper spraying. The effects secured from this equipment could be compared to the washing from a garden hose. It was rather assured that the coverage secured from such spraying would be very poor. Though on the lower limbs of some trees the foliage was well covered, the new growth, upon which the budworm larvae were feeding, remained fairly free from poison. This was believed to be the direct result of inefficient mixing of the spray materials and the lack of sufficient pressure to break the stream of liquid into the fine settling mist essential for proper spraying. During the past season it was found that there were yet other factors contributing towards this phase of the problem.

Following the application of this spray there was a fairly heavy mortality of the larvae on trees, or limbs, where the buds had been fully opened at the time the spray was applied. However, many larvae escaped due to the fact that they had apparently been protected by unopened buds or cases of needles. Though a rather large per cent of the larvae on that portion of the trees reached by the spray were destroyed, an examination

made later in the season showed that there were little tangible effects to be seen in the decrease in the defoliation. However, the areas treated were heavily infested and the lack of tangible evidence could perhaps be explained by the fact that larvae, forced by food shortages, dropped from the upper unsprayed portions of the crown to the lower foliage, from which the poison had perhaps been washed by heavy rains, and completed the defoliation started at the time the tree was treated. As only a small portion of each area was treated, larvae could have also migrated, or have been been blown from untreated trees adjacent.

In summarizing this project it must be said that it was difficult to see any beneficial results following this experimental spraying. However, with the makeshift equipment in use, it was evident that the tests as conducted could not be considered as being adequate or decisive, and that further experiments with proper equipment on a more extensive scale were necessary before final conclusions could be drawn. Though it was realized that due to the feeding habits of this insect it would prove to be a very difficult one to control through the application of a stomach poison, it was believed that if the spray could be applied at the proper time, and with efficient equipment, it would prove effective.

1930 OPERATION

In view of the importance of the spruce budworm infestation within the Cody Canyon, an appropriation of $10,000 was made available to the Bureau of Entomology to attempt the protection of the infested trees along the roadsides and around the summer homes and resorts. As a matter of convenience in the administration of this fund, $7,500 was transferred to the office of the Forest Supervisor, Shoshone National Forest, for the payment of laborers, purchase of supplies, etc. Due to the rather large appropriation, the extent of the area to be covered, and the short period of time in which to work due to the rapid development of the foliage, the project lost the aspects of research or investigations, and became one of actual control. Though such a development was not as desired, it was expected, as it was realized that the seriousness of the situation demanded that immediate steps be taken to protect the values at stake. Though it is recognized that a new problem of this character should be intensively studied before actual control projects are instituted, the seriousness of the situation seemed to warrant such action, as it was believed that with proper equipment, there was a good chance that the insect could be destroyed. Under such a program, which was practically decided by the size of the appropriation, it was necessary to plan this project on the basis of control rather than investigation, and the standard lead-arsenate, fish-oil spray solution was adopted as the one offering the most chances of success. Though because

of the short working season it was necessary to organize on a rush control basis, which excluded extensive experimentation with various insecticides, it was planned to determine through a series of temporary sample plots the most effective combination of these spray materials.

To carry on this project, the high-power Fitzhenry Guptill sprayer owned by the National Park Service, was secured from the Yellowstone National Park. This equipment is similar to the sprayers used in the New England States for the control of the gypsy moth, and was indeed satisfactory for the spraying of tall forest trees. The pump was capable of developing 1200 pounds pump pressure, which was more than ample to give the necessary 300 pounds nozzle pressure, through 1500 feet of hose and a lift of several hundred feet. There were 1100 feet of hose with the sprayer, and an additional 400 feet were purchased, as this amount was necessary to reach some of the summer homes and resorts on the opposite side of the river from the road.

This project started on June 13, 1930, and closed on July 7. At the time the project closed a large per cent of the larvae were mature and many pupae were present. However, the spraying was continued perhaps longer than effective, under an assumption that the greatest damage to the trees might possibly occur from the few days feeding of mature larvae.

As stated, the effective working time of this project was very short, as with a stomach poison it was necessary to wait until the leaf buds were opened before applying the spray. As the buds start to swell, the overwintering larvae bore into them and remain until they open. As the larvae mature very rapidly, there is only a relatively short period

for the application of a spray after the buds have opened, if the larvae are to be destroyed before the foliage is severly injured. Soon after the start of this project it was very evident that the area for which treatment was desired could not be covered in the allotted time by working only one shift of eight hours. Therefore, the previous organization was changed, and on June 20, two eight-hour shifts were started. The first shift started at 4 a.m. and were relieved by the second shift at 7 a.m. who worked until 12 p.m. At 12 p.m. the first shift were on duty again and continued until 5 p.m., when they were relieved by the second crew who continued until 8 p.m. In this way, the pumper was kept running continuously for sixteen hours.

Some difficulty was experienced with minor breakdowns and repairs, but in all the project ran very smoothly and efficiently. To augment the efficiency of the work, and to keep the spray equipment as busy as possible, two horse-drawn tanks were secured to haul water to the sprayer in order to eliminate the time required for the moving of this heavy and slow equipment to places where the water could be drawn from the river. When permanent sets were made at streams, the teamsters assisted in the laying and handling of the long lines of hose used. Each crew consisted of a nozzle man, four hose men and a mechanic who operated the pump. A Field Assistant of the Bureau of Entomology was in charge of each crew, while the writer was in general charge of the organization until the 24th of June, when the project was turned over to Mr. Lopp, Senior Field Assistant.

Practically all of the data secured in relation to this project was secured by Messrs. Miller and Lopp. The writer has experienced considerable difficulty in working up this data, and it is possible that

there may be some slight differences existing in the financial statement following:

ANALYSIS OF COSTS OF 1930 OPERATION

Disbursed by Forest Service:	
Labor	$1,767.02
Spray Material	1,991.55
Subsistence	384.88
Freight, Spray Material, Equipment, Etc	242.56
Gas and oil, (sprayer and small trucks)	286.82
Equipment	989.86
Miscellaneous--telegraph, etc	7.96
	$5,670.65
Disbursed by Bureau of Entomology:	
Salaries and expenses of Lopp and Miller, Field Assistants, Bureau of Entomology	$1,354.98
Total expenditure	$7,025.63
Balance on hand (both Bureaus)	$2,974.37
	$10,000.00

Though the above figures show the total cost of the project, including the salaries, materials, subsistence, etc., of men employed to carry on this work, as well as to check the results, it would seem that some of the items should be explained in further detail.

Labor

Applying Spray	$1,026.85
Teams and teamsters	384.00
Repairing Spray Truck	148.90
Cooking	122.52
Flunkeying	55.50
Setting up Camp	12.75
Watching Camp (July 4.)	3.00
Experimental spraying in August	13.50
	$1,767.02

Spray Material

Lead Arsenate	$1,668.00
Fish Oil	248.00
Volck for Ovicide Experiment	25.20
Black Leaf 40 Ovicide Experiment	42.40
Linseed Oil, etc.	7.95
	$1,991.55

Subsistence

Includes only the meals served at camp during the actual spraying operation.

Total	$ 384.88

Freight

Lead Arsenate	$ 106.54
Fish Oil	39.21
Volck	11.75
Hauling--Cody to Camp	106.08
Subsistence supplies from Denver, Colorado	51.01
	$278.59
Credit (overcharge?)	36.03
	$242.56

Gas and Oil

This material was used for both the sprayer and the small Ford trucks used in connection with this project. It is regretted that no record was maintained as to the actual use of gas and oil by the sprayer.

Total cost for Gas & Oil	$286.82

Equipment

Ford Truck	$595.50
Seasonal Repairs Ford Truck	24.74
High Pressure Hose (400 feet)	268.00
Worthley Nozzle (large)	31.03
Hose Gaskets	10.55
Suction Hose and Couplings	14.58
Pump Valves	18.68
Goggles	3.75
Mess Gear	8.50
Nozzle Tips (extra) and Shoulder Strap	13.93
Valve Grinding compound	.60
	$989.86

Miscellaneous

Telegraph	$1.00
Poison Labels	6.90
	$7.90

Though the foregoing data represent the total cost of the project for the season of 1930, it would seem necessary to isolate those items directly chargeable to the actual spraying, in order that a control cost figure can be computed.

ALLOCATION OF PROJECT COSTS

Items	Cost for Spraying	Cost per tank of spray based on 340 tanks	Cost of experiments Checking results, etc.
Labor			
Applying Spray	$1,026.85	$3.020	
Teams and teamsters	384.00	1.129	
Cooking	122.52	.360	
Flunkeying	55.50	.163	
Setting up camp	12.75	.037	
Watching camp	3.00	.008	
Experimental spraying			$13.50
Repairing Spray Truck			148.90
Spray Material	$1,916.00	5.635	75.55
Subsistence	384.88	1.132	
Freight	230.81	.678	11.75
Gas and oil	230.00	.676	56.82
Equipment			
Ford Truck			595.00
Repairs on Ford Truck			24.74
All other equipment	369.62	1.087	
Miscellaneous	7.96	.023	
Salaries and expenses of Lopp and Miller, Field Assistants, Bureau of Entomology	375.00	1.102	979.98
	$5,118.89	$15.050	$1,906.78

The item of repairs on truck has not been listed as a direct charge against the spraying operation. At the close of the project the sprayer was not in very good shape, and the motor and pump were thoroughly overhauled. Inasmuch as it was necessary to spend considerable time on this equipment before the start of the work, it would seem rather unfair to charge both maintenance charges against the project.

Though these figures show a total cost of $5,118.89 or $15.05 per tank of 400 gallons of spray, it would seem necessary to credit this charge with such items that have not been totally expended. A list of such items follows:

ASSETS AND EQUIPMENT ON HAND

3864 pounds Lead Arsenate @ $1.38	$533.23
Fish Oil 68 gallons @ 62¢	42.16
Worthley Nozzle (less 20% depreciation)	24.83
Nozzle Tips and Strap (Less 20% depreciation)	11.15
Suction Hose (less 20% depreciation)	11.67
Pump Valves (New)	18.68
Gaskets (less 25% depreciation)	8.02
High Pressure Hose (less 20% depreciation)	214.40
Assets on Hand	$863.91

These assets reduce the total cost of the spraying project from $5,118.89 to $4,254.98 and in turn lower the cost for each tank (400 gallons) to $12.51, and the cost per average tree to $0.10.

Though from the above data the cost per tank of spray as well as the spraying of an average tree is given, it would seem necessary to show what these figures may mean in computing the cost of treating other areas. It is regretted that an acreage charge, or some other more tangible factor of measurement could not have been secured. Though an attempt was made to establish the cost of spraying on an average acre, it was soon found that the timber type was so variable as to density and height of trees, that it was practically impossible. It was therefore necessary to determine the average number of trees of a certain height that could be sprayed with one tank, or 400 gallons of spray. In using this information as a basis for determining the cost of treating other areas, it would of course, be necessary to reduce the contemplated project to an acreage, and number of trees per acre basis. Though recognized as a very roundabout method, it

is believed that a fairly accurate determination of the cost of such a project can be secured.

SPRAYING STATISTICS

Number of tanks (400 gallons of spray applied)	340
Cost per tank	$12.51
Total number of trees sprayed	42,160
Average number of trees sprayed per tank	124
Average height of trees sprayed	30'
Cost of sprayed average tree	$0.1008

ANALYSIS OF LABOR

Wage Scale

Chief Mechanic (without board)	$6.80	per day.
Assistant Mechanic (without board)	5.00	" "
Nozzlemen	4.00	" "
Hosemen	3.00	" "
Cooks	5.00	" "
Flunky	3.00	" "
Team, Driver, Tank, and Wagon	8.00	" "

Crews

2 crews organized as follows:
- 1 Nozzleman
- 5 Hosemen
- 1 Mechanic and Truck Driver

2 teams, drivers, and tank wagon, were employed
1 cook and flunky.

Man Days

There were 374 man days, exclusive of overhead, but including cooks, flunkys, and teamsters, and 48 team days required in the application of 340 tanks of spray. The number of tanks applied during an eight-hour shift varied from 1¼ to 4. Minor breakdowns, inaccessability of water, inclemency of weather, and long moves are responsible for this marked

variation in the daily output.

Average tanks applied per Man Day.....1.1

Total cost per man day based upon $4,254.98 as the actual cost of the project.....$11.38

This apparent excessive cost per man day, which is exclusive of overhead, is due to the cost of the spray materials, operation of spray truck, equipment, etc.

Cost per man day including all labor charges, teams, subsistence and overhead is but $6.32, which is a very reasonable charge.

Subsistence

The total charges for subsistence were $562.90, which includes supplies, cook and flunkey. There were 1160 meals served in camp, at a cost of $0.48 per meal or $1.44 per man day. It would seem that this is a very reasonable cost, inasmuch as the working of two shifts necessitated the serving of a lunch at 3:30 a.m. and again at 8:30 p.m. in addition to the regular meals.

RESULTS SECURED FROM SPRAYING OPERATION

The determination of the results secured from this project was a rather difficult problem. Though it was recognized that the condition of the trees at the close of the feeding season, as judged by their general appearance, would be the final test, rather extensive data were taken in the hope that the results might be measured a trifle more accurately. In addition to the 11 plots that were established, on which different strength formulas were used, all of the Dude Ranches, and summer home colonies were more or less intensively studied in order to determine the actual effects of the spray. Not only were general observations taken at all these areas, but a series of "tip injury" counts were made on five sprayed and five unsprayed trees in each area. One hundred tips (1930 growth) were examined at the base, middle, and tops of these ten trees, and the degree of injury determined for each tip. All tips which harbored a larvae at the start of the season showed some injury. Where tips show a severe injury (50-100% defoliation) it can be assumed that the insect was not destroyed and fed upon the foliage until maturity was reached. Where tips show but a slight injury, one must assume that the feeding larvae were either destroyed by the spray, or else migrated for some reason. However, one would assume that there would be the same migration from the untreated trees, so if the frequency of these slightly injured tips was greater on the treated trees, one could assume that at least the difference was the direct result of the treatment. From a study of the following data it would seem that the degree of coverage secured had a direct bearing upon the results. A brief presentation of the data secured from each of these areas follows:

LAZY BAR H DUDE RANCH

June 13, 1930 - Sprayed.
Formula - 20% L.A. 3 qts. F.O. 400 gal. water.
Foliage - Buds just opening
July 14, 1930 - General examination.
Adults - many; Pupae, many; Larvae, few.
Coverage - very good.
Injury - Sprayed trees, very light; check trees, light.
July 23, 1930

Tip counts were made of 5 treated and 5 untreated trees. 100 new growth tips were examined at the base, middle, and top of each tree, making a total count of 1500 treated and 1500 untreated tips.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES BASED ON TIP COUNTS

Class of trees		Degree of injury to tip				
		None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	1370	57	49	18	6
	% of Tips:	91.3	3.8	3.2	1.2	.4
Unsprayed	No. of Tips:	1312	59	47	41	41
	% of Tips:	87.4	3.9	3.1	2.7	2.7

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage trees treated: Good 1100 Tips	Medium 400 Tips	Poor	Unsprayed Trees
None	No. of Tips:	1027	343		1312
	% of Tips:	68.4	22.9		87.4
0-30%	No. of Tips:	30	27		59
	% of Tips:	2.0	1.8		3.9
30-60%	No. of Tips:	27	22		47
	% of Tips:	1.8	1.5		3.1
60-90%	No. of Tips:	12	6		41
	% of Tips:	.8	.4		2.7
100%	No. of Tips:	4	2		41
	% of Tips:	.3	.1		2.7

The infestation in this region was very light, so it is rather difficult to draw any conclusions from the above data, though it would seem that there was very little difference between the sprayed and unsprayed trees. Data shows that 2.6% of the foliage on the sprayed trees was injured as against 6.6% on the untreated trees.

June 14, 1930 - Applied spray.
Formula - 28# L.A. 4 qts. F.O. 400 gal. water.
Foliage - Buds well opened. New growth complete
Infestation - Very heavy
July 14, 1930 - General examination.
Adults - Very many; Pupae, very many; Larvae, few.
Coverage - Poor
Injury - Sprayed trees, severe; check trees, very severe.
July 24, 1930 - Tip counts made of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of trees		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	772	173	114	115	326
	% of Tips:	51.4	11.5	7.6	7.6	21.7
Unsprayed	No. of Tips:	7	5	8	35	1445
	% of Tips:	.5	.3	.5	2.3	96.3

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to Tips		Degree of coverage on foliage: Good 500 Tips	Medium 300 Tips	Poor 700 Tips	Unsprayed Trees 1500 Tips
None	No. of Tips:	403	158	211	7
	% of Tips:	26.9	10.5	14.1	.5
0-30%	No. of Tips:	47	43	83	5
	% of Tips:	3.1	2.9	5.5	.3
30-60%	No. of Tips:	26	29	59	8
	% of Tips:	1.7	1.9	3.9	.5
60-90%	No. of Tips:	14	30	71	35
	% of Tips:	.9	2.0	4.7	2.3
100%	No. of Tips:	10	40	276	1445
	% of Tips:	.7	2.7	18.4	96.3

Though the general results secured were far from satisfactory, from the above data it is evident that there is a marked difference in the defoliation of treated and untreated trees. This difference can be seen in the 772 uninjured tips on the treated trees as against 7 on the untreated, and with the 1445 tips with 100% injury on the unsprayed with only 326 on the untreated. These data show a total defoliation of 33% for the treated and 97% for the untreated trees. There would also seem to be a rather distinct correlation of injury to the degree of coverage.

BLACKWATER DUDE RANCH

June 17, 1930 - Applied spray
Formula - 2½ L.A. 3 qts. F.O. 400 gal. water.
Foliage - Buds fully opened
Infestation - Heavy
Weather - Showers, Windy.

July 14, 1930 - General examination
Adults - Very many; Pupae, very many; Larvae, few
Coverage - Fair to poor
Injury - Severe on both sprayed and unsprayed trees.

July 25, 1930 - Made tip count of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of trees		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	668	121	200	176	345
	% of Tips:	44.2	8.0	13.2	11.6	22.8
Unsprayed	No. of Tips:	133	45	72	205	1067
	% of Tips:	8.8	2.9	4.8	13.3	70.2

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to Tips:		Degree of coverage on foliage: Good 600 tips	Fair 300 tips	Poor 610 tips	Untreated Trees 1522 tips
None	No. of Tips:	347	208	113	133
	% of Tips:	23.0	13.8	7.5	8.8
0-30%	No. of Tips:	68	19	34	45
	% of Tips:	4.5	1.3	2.3	2.9
30-60%	No. of Tips:	98	35	67	72
	% of Tips:	6.5	2.3	4.4	4.8
60-90%	No. of Tips:	67	20	89	205
	% of Tips:	4.4	1.3	5.9	13.3
100%	No. of Tips:	20	18	307	1067
	% of Tips:	1.3	1.2	20.3	70.2

From the above tables a marked difference in the defoliation between the sprayed and unsprayed trees can be seen. This can be noted in the tips uninjured, and those showing a 100% injury. These data show a 42% destruction of foliage on the sprayed trees, and 83% on the untreated. There is a relationship between the coverage and the per cent of injury, though there are some departures.

June 21, 1930 - Applied spray
Formula - 2# L.A. 4 qts. F.O. 400 gal. water.
Foliage - Buds well opened. New growth complete.
Infestation - Heavy
Weather - Good
July 14, 1930 - General examination
Adults - few; Pupae, many; Larvae, few.
Coverage - Good
Injury - Sprayed trees, light; check trees, severe.
July 25, 1930 - Tip counts made of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of Trees		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%	
Sprayed	No. of Tips:	991	126	131	137	115	1500
	% of Tips:	66.1	8.4	8.7	9.1	7.7	
Unsprayed	No. of Tips:	30	21	51	121	1278	1501
	% of Tips:	2.0	1.4	3.4	8.1	85.1	

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to tips:		Degree of coverage on foliage: Good 1100 tips	Fair 100 tips	Poor 300 tips	Unsprayed Trees 1501 tips:
None	No. of Tips:	814	40	137	30
	% of Tips:	54.3	2.7	9.1	2.0
0-30%	No. of Tips:	75	17	34	21
	% of Tips:	5.0	1.1	2.3	1.4
30-60%	No. of Tips:	66	22	43	51
	% of Tips:	4.4	1.5	2.9	3.4
60-90%	No. of Tips:	82	13	42	121
	% of Tips:	5.5	.9	2.8	8.1
100%	No. of Tips:	63	8	44	1278
	% of Tips:	4.2	.5	2.9	85.1

There exists in the above data the same marked difference in the numbers of uninjured tips and those showing a 100% injury between the sprayed and unsprayed trees. The destruction of foliage on the sprayed trees is shown as 19.7% as against 93% on the unsprayed. The same relationship exists between the coverage and injury, though departures continue to occur.

ELEPHANT HEAD LODGE

June 21, 1930 - Applied spray
Formula - 24% L.A. 4 qts. F.O. 400 gal. water
Foliage - Buds well opened.
Infestation - Heavy
Weather - Good
July 24, 1930 - General examination
Adults - few; Pupae, many; Larvae, few.
Coverage - Fair to good
Injury - Sprayed trees, light; check trees, severe.
July 26, 1930 - Tip counts of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of trees		Degree of Injury to tip. None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	886	191	191	161	81
	% of Tips:	58.7	12.6	12.6	10.7	5.4
Unsprayed	No. of Tips:	31	27	39	67	1336
	% of Tips:	2.0	1.8	2.6	4.5	89.1

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to tips:		Degree of coverage on foliage: Good 700 tips	Fair 710 tips	Poor 100 tips	Untreated Trees 1500 tips
None	No. of Tips:	394	458	34	31
	% of Tips:	26.1	30.3	2.2	2.0
0-30%	No. of Tips:	103	70	18	27
	% of Tips:	6.8	4.6	1.2	1.8
30-60%	No. of Tips:	91	82	18	39
	% of Tips:	6.0	5.4	1.2	2.6
60-90%	No. of Tips:	75	70	16	67
	% of Tips:	5.0	4.6	1.1	4.5
100%	No. of Tips:	37	30	14	1336
	% of Tips:	2.5	2.0	.9	89.1

The data in the above tables show the same trend as in those previously submitted. There is the same marked differences in the number of uninjured tips as well as those showing a 100% defoliation. The treated trees show a 21% destruction of foliage, as against a 93% for the untreated. Some correlation exists between the coverage secured and the degree of injury.

HOLM LODGE

June 23, 1930 - Applied spray.
Formula - 2½ L.A. 4 qts. F.O. 400 gal. water.
Foliage - Buds well opened.
Infestation - Medium morning.
Weather - Good Fairly heavy.
July 14, 1930 - General examination.
Adults - few; Pupae, many; Larvae, few.
Coverage - Fair to good.
Injury - Sprayed trees, light; check trees, medium.
July 26, 1930 - Tip counts made of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of trees:		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%:
Sprayed	No. of Tips:	625	125	188	192	370
	% of Tips:	41.7	8.3	12.5	12.8	24.7
Unsprayed	No. of Tips:	-	-	-	-	1500
	% of Tips:	-	-	-	-	100

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to tips:		Degree of coverage on foliage: Good 900 Tips	Fair 200 Tips	Poor 400 Tips	Unsprayed Trees 1500 Tips:
None	No. of Tips:	450	51	124	-
	% of Tips:	30.0	3.4	8.3	-
0-30%	No. of Tips:	76	6	43	-
	% of Tips:	5.1	.4	2.9	-
30-60%	No. of Tips:	82	16	90	-
	% of Tips:	5.5	1.1	6.0	-
60-90%	No. of Tips:	85	38	79	-
	% of Tips:	5.7	2.5	5.3	-
100%	No. of Tips:	207	89	64	1500
	% of Tips:	13.8	5.9	4.3	100

The above data are more striking than those previously submitted, in that all of the 1500 tips on untreated trees show a 100% defoliation against 370 for the treated trees. It is necessary to consider the untreated trees adjacent to the plot as being 100% defoliated, while the data show that on the treated trees a 41% defoliation occurred. Some correlation existing between coverage and degree of injury.

HOLM LODGE

June 23, 1930 - Applied spray
Formula - 2# L.A. 4 qts. F.O. 400 gal. water.
Foliage - Buds well opened.
Infestation - Medium
Weather - Good
July 14, 1930 - General examination
Adults - few; Pupae, many; Larvae, few.
Coverage - Fair to good.
Injury - Sprayed trees, light; check trees, medium.
July 26, 1930 - Tip counts made of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of trees		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	625	125	188	192	370
	% of Tips:	41.7	8.3	12.5	12.8	24.7
Unsprayed	No. of Tips:	-	-	-	-	1500
	% of Tips:	-	-	-	-	100

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to tips		Degree of coverage on foliage: Good 900 Tips	Fair 200 Tips	Poor 400 Tips	Unsprayed Trees 1500 Tips
None	No. of Tips:	450	51	124	-
	% of Tips:	30.0	3.4	8.3	-
0-30%	No. of Tips:	76	6	43	-
	% of Tips:	5.1	.4	2.9	-
30-60%	No. of Tips:	82	16	90	-
	% of Tips:	5.5	1.1	6.0	-
60-90%	No. of Tips:	85	38	79	-
	% of Tips:	5.7	2.5	5.3	-
100%	No. of Tips:	207	89	64	1500
	% of Tips:	13.8	5.9	4.3	100

The above data are more striking than those previously submitted, in that all of the 1500 tips on untreated trees show a 100% defoliation against 370 for the treated trees. It is necessary to consider the untreated trees adjacent to the plot as being 100% defoliated, while the data show that on the treated trees a 41% defoliation occurred. Some correlation existing between coverage and degree of injury.

ARTIST COLONY HOMES

June 20, 1930 - Applied spray.
Formula - 2#½ L.A. 4 qts. F.O. 400 gal. water.
Foliage - Buds well opened.
Weather - Rain early morning.
Infestation - Fairly heavy.

July 14, 1930 - General examination.
Adults- Very few; Pupae, few; Larvae, few.
Injury - Sprayed trees, medium; check trees, medium.
Coverage - Fair to good.

July 29, 1930 - Tip counts of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of trees:		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	1030	46	114	188	135
	% of Tips:	68.1	3.0	7.5	12.4	8.9
Unsprayed	No. of Tips:	477	22	79	165	757
	% of Tips:	31.8	1.5	5.3	11.1	50.1

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to tips:		Degree of coverage on foliage Good 713 tips	Fair 500 tips	Poor 300 tips:	Untreated Trees 1500 tips
None	No. of Tips:	567	309	154	477
	% of Tips:	37.5	20.4	10.2	31.8
0-30%	No. of Tips:	13	8	25	22
	% of Tips:	.9	.5	1.7	1.5
30-60%	No. of Tips:	32	53	29	79
	% of Tips:	2.1	3.5	1.9	5.3
60-90%	No. of Tips:	72	67	49	165
	% of Tips:	4.8	4.4	3.2	11.1
100%	No. of Tips:	29	63	43	757
	% of Tips:	1.9	4.2	2.8	50.1

There would seem to be no general difference in the trend of the above data from that previously submitted. Some marked differences exist, with the total defoliation of treated trees being 22% as against 61% for the untreated.

POWELL COLONY HOMES

June 24, 1930 - Applied spray.
Formula - 2½% L.A. 4 qts. F.O. 400 gal. water.
Foliage - Buds well opened. New growth complete.
Infestation - Heavy, 1930 injury pronounced.
Weather - Showers, hindered work.
July 14, 1930 - General examination.
Adults - Very few; Pupae, few; Larvae, few.
Injury - Sprayed trees, heavy; check trees, heavy.
Coverage - Fairly good.
July 28, 1930 - Tip counts of 5 treated and 5 untreated trees.

GENERAL COMPARISON OF SPRAYED AND UNSPRAYED TREES
BASED ON TIP COUNTS

Class of Trees		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	895	88	113	138	272
	% of Tips:	59.4	5.8	7.5	9.2	18.1
Unsprayed	No. of Tips:	126	27	66	188	1116
	% of Tips:	8.3	1.8	4.3	12.3	73.3

COMPARISON OF TIPS INJURED ON SPRAYED AND UNSPRAYED TREES
BASED ON FOLIAGE COVERAGE

Degree of Injury to tips		Degree of coverage on foliage: Good 1106 tips	Fair 200 tips	Poor 200 tips	Unsprayed Trees 1523 tips
None	No. of Tips:	722	173	-	126
	% of Tips:	47.9	11.5	-	8.3
0-30%	No. of Tips:	79	8	1	27
	% of Tips:	5.2	.5	.7	1.8
30-60%	No. of Tips:	100	10	3	66
	% of Tips:	6.6	.6	.2	4.3
60-90%	No. of Tips:	99	6	33	188
	% of Tips:	6.5	.4	2.2	12.3
100%	No. of Tips:	106	3	163	1116
	% of Tips:	7.0	.2	10.8	73.3

The above data show the same general trend as shown in that submitted from other areas. Some marked differences in the treated and untreated trees as evidenced by the tips with no injury, and those with destruction 100%. The treated trees show an average defoliation of 29% as compared to 84% on the untreated.

SUMMARY OF TIP COUNT DATA

A detailed summary of the preceding tables is hardly necessary, as the data in all of them follow the same general trend. However, the data from all of these areas have been compiled into the following table, which can be taken as the average result obtained.

COMPARISON OF SPRAYED AND UNSPRAYED TREES ON ALL OF THE AREAS BASED ON TIP EXAMINATIONS

Class of trees:		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed	No. of Tips:	7237	927	1100	1125	1650
12,039 tips	% of Tips:	60.11	7.69	9.14	9.34	13.70
Unsprayed	No. of Tips:	2116	206	362	822	8540
12,046 tips	% of Tips:	17.56	1.71	3.00	6.82	70.89

Average per cent of foliage destroyed
Sprayed trees, 25.98%; Unsprayed, 77.62%

In measuring the degrees of success as shown by these data, it would seem that the difference between the per cent of defoliation on the sprayed and unsprayed trees would show the effects of the spray, which from the above table would be 51.64%. This figure is greater than one would assume from general observations in the area, as in August, 1930, it was rather difficult to visualize any benefits secured from the spray.

There are several somewhat intangible points in the foregoing table that would seem to be worthy of comment. One of these is the fact that there were more tips showing intermediate stages of injury on the treated than on the untreated trees, when one would perhaps feel that conditions should be reversed. This can be explained through the injury that had already occurred at the time the spray was applied. In the application

of this spray it is necessary to wait until a large per cent of the buds have opened, so by the time those at the base of the tree have opened, considerable damage will have occurred to the earlier opened buds on the upper portion. Therefore, at the time the spray is applied, even though it be very effective, there will remain the varying degrees of injury that were present at the time. On the untreated trees, the lesser stages of injury will not be so numerous, as the larvae would continue in their development leaving more 100% defoliated tips. It is also true that some of the partially defoliated tips resulted from larvae leaving completely defoliated tips and feeding for a short period on others before pupation.

Though it is believed that the difference between the average defoliation of the treated and untreated trees gives the best measurement of success, which in this instance is 51.6%, the difference between the occurrence of the uninjured as well as 100% defoliated tips is significant. These data for treated trees, show an increase of 232.5% in the number of uninjured tips, when compared with untreated trees, and a decrease of 80.7% in the number showing 100% injury.

Though there is a distinct correlation between the degree of coverage and the injury to the foliage, it is not as pronounced as one might expect. The degree of injury in the "Good" and "Poor" classifications of coverage compare favorably as to what one would expect to find. However, the data under the "Fair" classification in some of the tables would seem to be somewhat out of step. Perhaps in some instances this occurred as a result of error in the assignment of the different trees to the classification of coverage. To overcome this possible objection, the data from all of the

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COMPARISON OF SPRAYED AND UNSPRAYED TREES ON ALL OF THE AREAS BASED ON TIP EXAMINATIONS

Class of trees:		Degree of Injury to Tips: None	0-30%	30-60%	60-90%	100%
Sprayed 12,039 tips	No. of Tips:	7237	927	1100	1125	1650
	% of Tips:	60.11	7.69	9.14	9.34	13.70
Unsprayed 12,046 tips	No. of Tips:	2116	206	362	822	8540
	% of Tips:	17.56	1.71	3.00	6.82	70.89

Average per cent of foliage destroyed
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of this spray it is necessary to wait until a large per cent of the buds have opened, so by the time those at the base of the tree have opened, considerable damage will have occurred to the earlier opened buds on the upper portion. Therefore, at the time the spray is applied, even though it be very effective, there will remain the varying degrees of injury that were present at the time. On the untreated trees, the lesser stages of injury will not be so numerous, as the larvae would continue in their development leaving more 100% defoliated tips. It is also true that some of the partially defoliated tips resulted from larvae leaving completely defoliated tips and feeding for a short period on others before pupation.

Though it is believed that the difference between the average defoliation of the treated and untreated trees gives the best measurement of success, which in this instance is 51.64%, the difference between the occurrence of the uninjured as well as 100% defoliated tips is significant. These data for treated trees, show an increase of 232.5% in the number of uninjured tips, when compared with untreated trees, and a decrease of 80.7% in the number showing 100% injury.

Though there is a distinct correlation between the degree of coverage and the injury to the foliage, it is not as pronounced as one might expect. The degree of injury in the "Good" and "Poor" classifications of coverage compare favorably as to what one would expect to find. However, the data under the "Fair" classification in some of the tables would seem to be somewhat out of step. Perhaps in some instances this occurred as a result of error in the assignment of the different trees to the classification of coverage. To overcome this possible objection, the data from all of the

areas have been compiled into one table showing the extent of injury according to degree of coverage.

COMPARISON OF TIPS ON ALL THE AREAS FROM SPRAYED AND UNSPRAYED TREES BASED ON FOLIAGE COVERAGE

Degree of Injury		Degree of coverage of treated trees: Good	Fair	Poor	Unsprayed Trees
None	No. of Tips:	4724	1740	773	2116
	% of Tips:	39.24	14.45	6.42	17.56
0-30%	No. of Tips:	491	198	238	206
	% of Tips:	4.08	1.64	1.98	1.71
30-60%	No. of Tips:	522	269	309	362
	% of Tips:	4.33	2.23	2.57	3.00
60-90%	No. of Tips:	506	250	379	822
	% of Tips:	4.20	2.08	3.15	6.82
100%	No. of Tips:	476	253	911	8540
	% of Tips:	3.95	2.10	7.57	70.89
	Total Tips	6719	2710	2610	12046
	Total %	55.85	22.50	21.69	100%

From the above table one will see that a good coverage was secured on 55.85% of the foliage, a fair coverage on 22.50% and a poor coverage on 21.69%. It will also be seen that there is a distinct relationship between the degree of injury and the coverage. Carrying these data still further, we find that only 17.32% of the foliage with a <u>good</u> coverage was destroyed, 21.82% of the foliage with a <u>fair</u> coverage, while 52.49% of the foliage with a <u>poor</u> coverage was destroyed.

SAMPLE PLOTS

As a test of the effectiveness of various strengths of lead arsenate and fish oil, a series of sample plots with suitable check areas, were established in different parts of the area covered. These plots were located along the roadside, and by the side of each, an area comparable in size was left untreated as a control upon the results obtained. These plots were covered by a general survey on June 22, and during the early part of August a more intensive examination was made. At that time 50 average trees were selected from both the sprayed and unsprayed portions of the plot, and the degree of defoliation and the character of the 1930 growth recorded from visual observation only. The trees were grouped into five different classifications of defoliation, based upon the general appearance of the tree, and of course, subject to human error in the interpretation of the degree of defoliation. The 1930 growth on each tree examined was listed as "Good" "Fair" and "Poor". The purpose of securing this information was to determine if any relationship existed between the degree of defoliation and the apparent vigor of the tree as indicated by the new growth. New growth data will not be included in the description of each plot, but will be presented in a summation of the data secured from all plots.

Cliff Creek Plot

Spray applied - June 30, 1930.

Injury to foliage at time of spraying - Medium.

Infestation - Heavy

Amount of spray used - 800 gallons.

Formula - 16# L.A., 2 qts. F.O., 400 gal. H20.

General survey of Plot July 22, 1930.

Coverage - Poor

Injury - Severe

Adult moths - Very many

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total Trees	Average Tree Defoliation
Sprayed No.of trees	0	8	16	22	4	50	71.2
Unsprayed No.of trees	0	4	9	9	28	50	84.1

These data show a difference in the total defoliation of treated and untreated trees of 12.9%, which can be credited to the effects of the spray. Though not a marked difference it is perhaps all that could be expected from the poor coverage secured with the light dosage of lead arsenate. Furthermore, there was a medium injury at the time the spray was applied, which was rather late in the season.

Goff Creek Plot

Spray applied - June 23, 1930

Injury to foliage at time of spraying - Little

Infestation - Light to medium

Amount of spray used - 1000 gallons

Formula - 16# L.A., 2 qts. F.O., 400 gal. H2O.

General survey of plot July 22, 1930

Coverage - Poor

Injury - Light to medium

Adult moths - Medium number

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation					Total Trees	Average Tree Defoliation
	0-25%	26-50%	51-75%	76-95%	96-100%		
Sprayed							
No. of trees:	12	11	17	10	-	50	49.5
Unsprayed							
No. of trees:		9	19	18	4	50	68.8

The above data shows a difference in defoliation of the treated and untreated trees, amounting to 19.3%. This reduction is larger than that secured on the Cliff Creek Plot, though the same formula was used. However, there was "little" injury to the foliage at the time the trees were sprayed, due no doubt, to the earlier date that the trees were treated. Though not a large reduction in defoliation, it is perhaps all that can be expected when the light dosage and resulting poor coverage is considered.

Elephant Head Plot

Spray applied - June 21, 1930

Injury to foliage when sprayed - Little

Infestation - Medium

Amount of spray used - 1200 gallons

Formula - 20% L.A., 4 qts. F.O., 400 gal. H20.

General survey of plot July 22, 1930.

Coverage - Very good

Injury - Light to medium

Adult moths - Very few

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total Trees	Average Tree Defoliation
Sprayed							
No.of trees:	1	29	9	9	2	50	52.4
Unsprayed							
No.of trees:	-	10	13	19	8	50	71.6

On this plot a reduction in the defoliation of treated trees amounting to 19.2% was secured. It would seem that better results should have been secured, as there was "little" injury to the foliage at the time the spray was applied, and a "very good" coverage was secured. This plot was sprayed rather early in the season, which was no doubt responsible for the light injury to the foliage at the time of the treatment. However, the infestation in this area was not very heavy. The trees were treated in 1929, and it is possible that the treatment resulted in some way in preventing a heavy oviposition during the egg laying period of that season.

Chimney Rock

Spray applied - June 29, 1930

Injury to foliage at time of spraying - Heavy

Infestation - Heavy

Amount of spray used - 800 gallons

Formula - 20% L.A., 4 qts. F.O., 400 gal. H20.

General survey of plot July 22, 1930.

Coverage - Good

Injury - Medium to severe

Adult moths - Medium number

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation					Total Trees	Average Tree Defoliation
	0-25%	26-50%	51-75%	76-95%	96-100%		
Sprayed							
No. of trees	-	2	16	26	6	50	77.4
Unsprayed							
No. of trees	-	-	8	24	18	50	85.9

The data above show but a slight difference between the treated and untreated trees amounting to 8.5%. As the injury to the foliage at the time the spray was applied was recorded as heavy, a much greater reduction could hardly have been expected, even though a good coverage was secured. This area was not sprayed until late in the season, and it is possible that the buds had been opened for some few days.

Gunbarrel Creek Plot

Spray applied - June 29, 1930

Injury to foliage at time of spraying - Heavy

Infestation - Medium

Amount of spray used - 1200 gallons

Formula - 2D# L.A., 5 qts. F.O., 400 gal. H2O.

General survey of plot July 22, 1930.

Coverage - Fair

Injury - Medium

Adult moths - Medium number

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total Trees	Average Tree Defoliation
Sprayed No.of trees	-	18	21	10	1	50	58.7
Unsprayed No.of trees	-	7	10	6	27	50	80.6

The data secured from this plot indicate that a decrease in the defoliation of the treated trees amounting to 21.9% followed the application of spray. Though not a marked reduction, it would seem about all that could be expected as the injury at the time of treatment was recorded as heavy, and only a "fair" coverage was secured.

Chimney Rock Camp Ground

Spray applied - June 22, 1930

Injury to foliage when sprayed - Heavy

Infestation - Medium

Amount of spray used - 1200 gallons

Formula - 20# L.A., 5 qts. F.O., 400 gal. H20.

General survey of plot July 22, 1930

Coverage - Poor

Injury - Medium

Adult moths - Many

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total Trees	Average Tree Defoliation
Sprayed No.of trees:		3	15	23	9	50	77.6
Unsprayed No.of trees:		4	16	28	2	50	74.5

From the above data it would seem that the spraying had not only had no effect in reducing the defoliation, but had resulted in an increase of 3.1%. The later premise is, of course, unsound, though there can be no doubt but that the treatment showed no beneficial effects. The injury at the time of treatment was recorded as severe, which with the poor coverage, could not be expected to produce very favorable results. The reason for the greater defoliation of treated trees is no doubt due to the improper selection of trees for examination, or incorrect interpretation of data.

Palisades Plot

Spray applied - June 30, 1930

Injury to foliage at time of spraying - Severe

Infestation - Heavy

Amount of spray applied - 800 gallons

Formula - 2½ L.A., 3 qts. Linseed Oil, 400 gal. H_2O.

General survey of plot July 22, 1930

Coverage - Very good

Injury - Severe

Adult moths - Many

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation					Total Trees	Average Tree Defoliation
	0-25%	26-50%	51-75%	76-95%	96-100%		
Sprayed No.of trees	-	4	11	21	14	50	79.7
Unsprayed No.of trees	-	-	9	24	17	50	85.2

Only a slight difference of 5.5% in the degree of defoliation existed between the treated and untreated trees. The only explanation as to why better results were not secured from this plot, is that the injury at the time the trees were treated was so severe that no possible benefits could follow. Three quarts of Linseed oil were used as an adhesive and a "very good" coverage secured.

Draw - East Holm Lodge Plot

Spray applied - July 2, 1930

Injury to foliage at time of spraying - Moderate

Infestation - Heavy

Amount of spray used - 800 gallons

Formula - 2# L.A., 3½ qts. F.O., 400 gal. H2o.

General survey of Plot July 22, 1930

Coverage - Very good

Injury - Medium

Adult moths - Many

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation					Total Trees	Average Tree Defoliation
	0-25%	26-50%	51-75%	76-95%	96-100%		
Sprayed							
No. of trees:	7	13	7	8	15	50	63.1
Unsprayed							
No. of trees:	26	13	6	5	136	50	89.4

The difference between the defoliation on the treated and untreated trees on this plot amounted to 26.3%, which can be credited to the treatment. A heavy dosage of lead arsenate was used, which resulted in a "very good" coverage. As the injury to the foliage at the time of treatment was not severe, and the general infestation within the area was heavy, it could be expected that fairly marked results would follow.

Draw - West Holm Lodge Plot

Spray applied - July 2, 1930

Injury to foliage at time of spraying - Moderate

Infestation - Heavy

Amount of spray used - 800 gallons

Formula - 25# L.A., 3½ qts. F.O., 400 gal. H20.

General survey of Plot July 22, 1930

Coverage - Very good

Injury - Medium

Adult moths - Many

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total Trees	Average Tree Defoliation
Sprayed No.of trees	7	13	7	8	15	50	63.1
Unsprayed No.of trees	-	1	8	5	36	50	89.4

The difference between the defoliation on the treated and untreated trees on this plot amounted to 26.3%, which can be credited to the treatment. A heavy dosage of lead arsenate was used, which resulted in a "very good" coverage. As the injury to the foliage at the time of treatment was not severe, and the general infestation within the area was heavy, it could be expected that fairly marked results would follow.

Kitty and Golf Creek Plot

Spray applied - June 28, 1930

Injury to foliage at time of spraying - Little

Infestation - Light

Amount of spray used - 800 gallons

Formula - 2#$ L.A., 3½ qts. F.O., 400 gal. H20.

General survey of plot July 22, 1930

Coverage - Very good

Injury - Light

Adult moths - Very few

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation					Total Trees	Average Tree Defoliation
	10-25%	26-50%	51-75%	76-95%	96-100%		
Sprayed							
No. of trees:	48	2	-	-	-	50	13.5
Unsprayed							
No. of trees:	28	13	6	2	1	50	29.6

The data from this plot show a difference of 16.1% in the defoliation of the treated and untreated trees. The infestation within this area was recorded as "light" and the injury to the foliage at the time of treatment as "little". A heavy dosage of lead arsenate was used and the resulting coverage recorded as "very good". It would seem that about the same difference exists between the treated and untreated trees, regardless of the severity of the infestation.

Swamp - West Holm Lodge Plot

Spray applied - July 5, 1930

Injury to foliage at time of spraying - Severe

Infestation - Heavy

Amount of spray applied - 1200 gallons.

Formula - 25% L.A., 5 qts. F.O., 400 gal. H20.

General survey of plot July 22, 1930

Coverage - Good

Injury - Medium to heavy

Adult moths - Many

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation					Total Trees	Average tree Defoliation
	0-25%	26-50%	51-75%	76-95%	96-100%		
Sprayed							
No.of trees:	34	14	1	1	-	50	21.9
Unsprayed							
No.of trees:	3	13	15	17	2	50	62.0

The data from this plot is rather hard to understand. Though a "good" coverage was secured, the injury to the foliage at the time of treatment was "severe" the general infestation heavy, and time of treatment late in the season. With these factors to consider it is rather difficult to understand why a difference of 40.1% should exist between the treated and untreated trees. It is possible perhaps that average trees were not selected for examination, which, of course, with such a small number examined would seriously influence the final results. However, a heavy dosage was used, which should have given good results.

Chimney Rock - Fishhawk Plot

Spray applied - June 28, 1930

Injury to foliage at time of spraying - Little

Infestation - Light

Amount of spray used - 800 gallons

Formula - 28# L.A., 5 qts. F.O., 400 gal. H20.

General survey of plot July 22, 1930

Coverage - Good

Injury - light

Adult moths - Very few

COMPARISON OF DEFOLIATION ON SPRAYED AND UNSPRAYED TREES

Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total: Trees	Average Tree Defoliation
Sprayed							
No.of trees:	13	13	16	7	1	50	46.8
Unsprayed							
No.of trees:	24	21	4	1	-	50	28.4

Here again are data difficult to explain. Why should there have been an increase in the per cent of defoliation of the treated trees when the data show extremely favorable conditions for a potential reduction? With the same formula as used for the Swamp Holm Lodge Plot, where a reduction of 40.1% was secured, little injury to the foliage at the time of spraying, light infestation, and good coverage, a marked reduction in the defoliation on the treated trees should have followed the treatment instead of an increase of 18.4%. It would almost seem that a mistake had occurred in the labeling of the field data, and that the records from the treated and untreated trees have been reversed. Though the writer sincerely believes that this is what occurred, the data have been presented in the manner as indicated by the Field Assistants.

SUMMARY OF RESULTS SECURED FROM PLOTS SPRAYED
WITH DIFFERENT COMBINATIONS OF LEAD ARSENATE AND FISH OIL

It would seem that the first reaction one has in studying the data secured from these sample plots, is the decidedly poorer results secured from these treatments than from around the dude ranches, summer homes, etc. Though it is true that on these areas, a different formula was used, which was expected to give the best results, this fact alone would not account for such a consistently poor showing on the plots. It would seem that a better explanation would be the two different methods of measuring the results. Around the dude ranches, a count of the injured tips was made from the base, middle, and tops of the trees, while on the sample plots, the degree of defoliation for each tree was determined through a visual estimate. Without some very detailed checks, which were not made, it is difficult to determine between the efficiency of these two methods. With one the degree of injury for each tip was made, while with the other, the defoliation for the entire tree was estimated. It would seem that the former method would prove the most accurate, as it eliminates most of the errors in judgment, and would seem to give a better determination of the actual defoliation. When a defoliated tree is observed, there may be a tendency to over estimate the actual destruction of the new growth. However, though it is believed that the tip counts should give the most accurate figure, the other method is sufficient to determine the effectiveness of the different spray formulas used.

There seems to be no positive trend of data relative to the actual reduction in the defoliation of the treated trees, and some of the de-

partures from what would be expected are difficult to explain. An increase in defoliation of treated trees over those used as controls, can not be credited to the effects of the spray. A better explanation would seem to lie in the improper selection of trees for examination, or an error in the interpretation of the degree of defoliation. When such a small amount of data is collected (50 trees) errors of this character are not easily absorbed, and materially influence the final results.

A tabulation of the character of the coverage and the degree of defoliation for each formula used follows:

RECAPITULATION OF RESULTS SECURED WITH DIFFERENT COMBINATIONS OF LEAD ARSENATE AND FISH OIL

Plot	Date Sprayed	Formula Used Based on 400 gallons water	Foliage coverage	Decrease in defoliation of treated trees
Cliff Creek	6/30/30	16#L.A.2 qts.F.O.	Poor	12.9%
Goff Creek	6/23/30	16#L.A.2 qts.F.O.	Poor	19.3%
Elephant Head	6/21/30	20#L.A.4 qts.F.O.	Very good	19.2%
Chimney Rock	6/29/30	20#L.A.4 qts.F.O.	Good	8.5%
Gunbarrel	6/29/30	20#L.A.5 qts.F.O.	Fair	21.9%
Chimney Rock Camp	6/22/30	20#L.A.5qts.Fe O.	Poor	3.1% Increase
Palisades	6/30/30	24# L.A. 3 qts. Linseed Oil	Very good	5.5%
Draw - West Holm Lodge	7/2/30	28#L.A.3½ qts.F.O.	Very good	26.3%
Kitty - Goff	6/28/30	28#L.A.3½ qts.F.O.	Very good	16.1%
Swamp Holm Lodge	7/5/30	28#L.A.5 qts.F.O.	Good	40.1%
Fishhawk - Chimney Rock	6/28/30	28#L.A.5 qts.F.O.	Good	18.4% increase

From the above tabulation it will be seen that a better coverage was secured with the heavier dosages of lead arsenate. Though these heavier dosages gave consistently good coverages, similar results were secured on the Elephant Head Plot with 20# of lead arsenate. On the Palisade Plot, 24# of lead arsenate used with linseed oil also gave a "very good" coverage. Contrary to this apparent correlation there did not seem to be any beneficial results gained from the use of large dosages of fish oil. The selection of formulas for general spraying and experimental work, was made in full cognizance of the previous work already conducted on the proper mixtures of lead arsenate and fish oil. However, as previous studies had for the most part been confined to deciduous trees, it was believed that some further tests were justified. Mr. C. E. Hood, Technical Bulletin #III U. S. D. A., gives the proper ratio of fish oil to lead arsenate as being 1 pt. of oil to 4# of poison. In the mixture adopted for general spraying it was realized that though 1 pt. of fish oil to 3# of lead arsenate was being used, it was hoped that in this way a maximum coverage on the new growth of the Douglas Fir trees might be secured. From a study of this data, there is no doubt but that more oil was used than was actually required, as very good coverages were secured with the ratio recommended by Mr. Hood.

The lack of correlation between the coverage secured and the results obtained, as shown by the difference in the defoliation of treated and untreated trees is not so very difficult to understand. Such factors as the proper selection and interpretation of data, condition of foliage at the time spray was applied, severity of infestation, degree of injury occurring before time of spraying, climatical condition, etc., all have a direct

bearing upon the results obtained even though a good coverage was secured. Regardless of this fact, it is evident that effective results cannot be secured without a good coverage.

In connection with the data taken relative to the degree of defoliation following the treatment of these plots, notes were secured relative to the character of the 1930 foliage, which was listed as good, fair, and poor. These data were secured as an index to the vigor of the tree, feeling that perhaps some correlation might exist between such vigor and the recorded injury. In the tabulation of each plot these data were omitted, as the writer failed to find the existence of any facts which might have a bearing upon the problem. However, the data from all of the plots, have been brought together into the following table. It is recognized that this is not a correct compilation as results from plots sprayed with different formulas have all been given the same relative weights. Furthermore, the writer fails to see any natural bearing that the data from this table have upon the problem under consideration.

TABLE SHOWING THE RELATION OF DEFOLIATION SECURED ON PLOTS SPRAYED WITH DIFFERENT STRENGTH FORMULAS, AND THE CONDITION OF THE 1930 GROWTH

1930 Growth	Trees	Degree of Defoliation 0-25%	26-50%	51-75%	76-95%	96-100%	Total Trees	Average Tree Defoliation
Good	Sprayed No.of trees	105	100	88	90	37	420	40.86
	Unsprayed No.of trees	51	65	74	81	84	355	54.59
Fair	Sprayed No.of trees	10	16	39	40	10	115	54.74
	Unsprayed No.of trees	4	16	33	52	34	139	66.04
Poor	Sprayed No.of trees	-	1	2	7	5	15	75.00
	Unsprayed No.of trees	-	1	10	20	25	56	78.57

From the above table one will see that there is a decided increase in the per cent of defoliation on the trees with "fair" and "poor" foliage over those with good. As stated, aside from an interesting correlation, the writer fails to find any beneficial information in these results.

OVICIDE EXPERIMENT

Due to the habit of the small overwintering budworm larvae boring into and feeding while concealed within the opening buds, it is impossible to destroy these insects during the larval period, before considerable damage to the new growth has occurred, as spray cannot be effectively applied before the buds have fully opened. With the thought of preventing all defoliation, the idea of destroying the eggs during the height of the egg laying season, through the application of an ovicide was developed. This experiment was planned on a rather small scale as there were several factors having a direct bearing upon the economic application of such a spray. The most important of these was the period of time over which oviposition occurred and the shorter time required for the eggs to hatch, which would require at least two and perhaps three applications of spray if all of the eggs were to be destroyed. However, in relation to this possible method of control, it was evident that the first step to be taken was the determination of the results to be expected from the use of an ovicide. Feeling that "Volck" offered the best possibilities as an ovicide, a small quantity was secured and applied on August 6, 1930. A 2% solution of this oil was used, and 1400 gallons of spray applied on an area that had not been previously sprayed with lead arsenate. At the time the spray was applied there were large numbers of unhatched egg masses to be found on the

foliage, and many moths were still flying and ovipositing. Following the spraying of this plot of trees, three different lots of tips were collected for examination. A tabulation of this data follows:

Lot #1 Tips taken from tree felled and sprayed heavily while lying on ground. This tree was fairly saturated with spray.

Lot #2 Tips taken from one especially heavily sprayed tree.

Lot #3 Tips taken from 25 different trees.

RESULTS OF EXAMINATION OF EGG MASSES
SPRAYED WITH 2% SOLUTION OF VOLCH
August 6, 1930

Lot #	Number of Egg Masses	Date examined	Partly Hatch	Fully Hatched
1	20	August 10	1	0
		August 16	2	1
2	43	August 10	10	6
		August 16	12	9
3	108	August 10	14	11
		August 16	17	15

From the above data it would seem that the ovicide had little or no effect in the destruction of the eggs. It is true that ten days after the spray applied, only 15% of the egg masses in Lot #1, 49% of Lot #2, and 30% of Lot #3 had hatched or started to hatch. It is regretted that further data were not secured from this material. However, the officers in charge were obliged to leave the area at that time, though they were both of the opinion that the spray had had no effect upon the egg masses, and that the remaining masses would hatch in a very few days. There are perhaps other ovicides that might have given more satisfactory results.

GENERAL SUMMARY OF PROJECT

The variation in the results secured from the 1930 project was influenced by the severity of the infestation, degree of injury and development of new growth at the time of treatment, as well as the coverage secured on the 1930 growth of needles. Of these factors, it would seem that coverage is perhaps the most important. Though not so difficult to secure a good coverage upon the old foliage, even a fair coverage on the new growth was an exception. Perhaps the fact that the new needles are smoother, and less resinous, would explain this difficulty. Furthermore, as the budworm larvae apparently feed on the base of the needles, the location of coverage must be considered in determining its effectiveness.

The prevention of injury prior to spraying is an impossibility. If a tree could be sprayed just as the new growth was opening, and the larvae destroyed, perhaps 75% of the defoliation could be prevented. However, as the buds open, the larvae mature rapidly and in a few days destroy a large per cent of the new growth of needles. It is impossible to spray all of an area, or even a single tree at just the right time, for the buds open at the top of the trees several days earlier than at the base. Perhaps a small area could be treated while in the most favorable condition for the application of a stomach poison spray, but by the time the operation had extended over a two or three weeks period, extensive damage would have resulted in the trees where the buds had been open for some time. Therefore, if the spray is to be made effective, it must be applied at the proper period in the development of the foliage, which, for

each area, would only last for a few days.

It is very evident that the spray as applied during the 1930 operation had a rather direct effect in reducing the degree of defoliation. However, the results were so varied, and at their best not sufficiently successful to warrant the recommendation of this treatment as used during the past season, as a method of control. The larval habit of feeding from the base of the needles, difficulty of securing a uniform coverage on the new growth, and the impossibility of spraying all trees just as the buds are opening, are factors which would seem to make the development of a poisonous spray a difficult one to contemplate.

One rather promising condition noted was the much lighter 1930 infestation on the trees treated in 1929. This condition was very evident at the Elephant Head Lodge, where the trees were rather well covered by spray in 1929. This occurrence gives rise to the thought that perhaps the presence of the spray acts as a repellent to the female moth and discourages oviposition.

The outstanding feature of this project, which is brought out by the results obtained, is the fact that due to the economic importance of this situation, control measures were instituted without the necessary intensive fundamental study of the problem such as is being planned for the season of 1931.

PLANS FOR THE 1931 SEASON

Though the results of the 1930 operation were very unsatisfactory, the writer cannot help but feel that a method of artificial control can be developed for the combating of this insect. A rather intensive program of

investigation is planned for the coming season. The balance of the appropriation will be sufficient to carry this project during the remainder of the present fiscal year, and Bureau funds will be used after July 1, 1931. All possible leads will be followed in attempting to control the insect in the different stages of its development. Further tests will be made with arsenical sprays in connection with different stickers and spreaders. If such sprays are to be effective they must be developed so that the new growth will be covered down to the base of the needles.

A German contact spray "Forestit" is now on the market, which will be tested in the hopes that it will give better results than stomach poisons. Other possibilities of contact sprays will be tested.

The possibilities of preventing oviposition upon trees of high aesthetic value, through the use of a repellent, offer some hopes. Different tests of this character will be conducted.

Further experimental work relative to the possibilities of using an ovicide in order to prevent all damage to the trees will also be conducted.

A high power sprayer has been secured for this project, and two field assistants will spend the entire season upon the project.

CONCLUSIONS

This report would seem to be a long method of presenting the rather small amount of negative results. The primary purpose of this paper was to place all data on record in order that it would be available to the Bureau officers conducting future studies of this character.

Perhaps the description of the individual plots and areas could have been omitted, but it was believed that their inclusion would prove of value to the officers in charge of this problem in 1931.

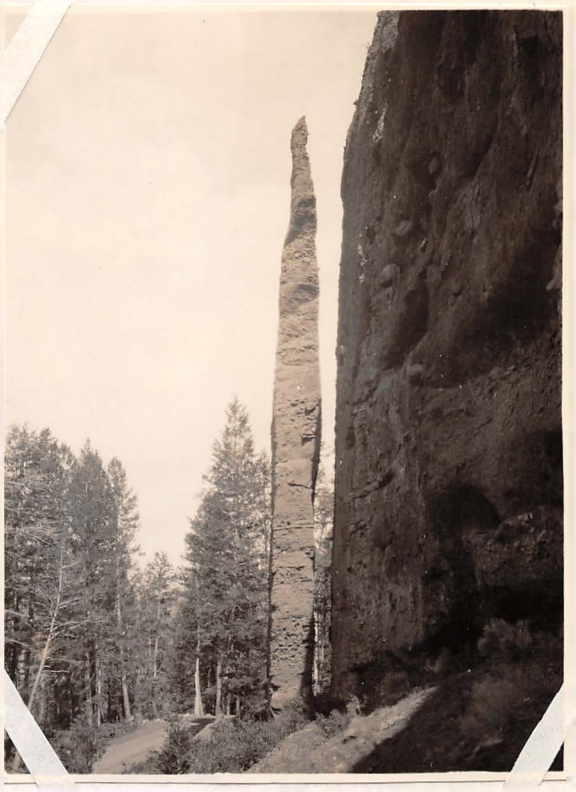
In concluding this report, the writer desires to express his appreciation of the splendid cooperation extended to the Bureau of Entomology by Region 2, of the Forest Service, in administration of the $7,500 transferred to them for vouchering, etc., as well as for other forms of cooperation. It is desired to especially mention Supervisor Langworthy, Executive Assistant Straub, and Ranger Spencer of the Shoshone National Forest. These men did everything within their power to make this project a success, and the writer wishes to express his appreciation of this cooperation.

Respectfully submitted,

James C. Evenden

James C. Evenden, Entomologist

A bit of roadside



Chimney Rock

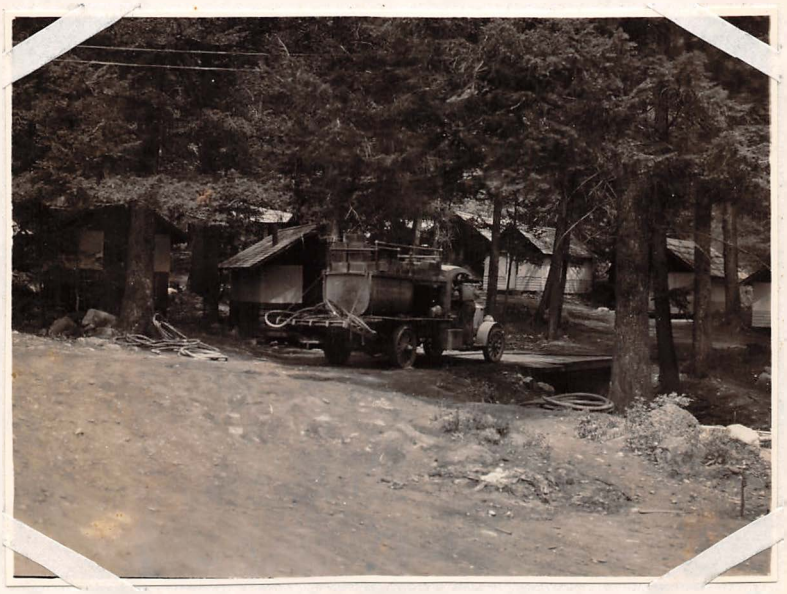
Roadside framed with aspen

Cody Gorge below the dam

Spraying of roadside..

Roadside spraying

Permanent set at Ramsey's Dude Ranch. 1500 feet of hose used to reach the trees surrounding this resort. Water pumped.



Permanent set at Holm Lodge. Showing the aesthetic value of Douglas Fir trees to the attractiveness of the site.